A Grand Unified Field Theory of Asymmetry: Spacetime and Gravity as Emergent Phases of the Dark Energy Quantum Field

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Abstract

We propose a Grand Unified Field Theory (GUFT) in which all known physical fields, including spacetime and gravity, emerge from a single foundational Dark Energy Quantum Field (DEQF). In this framework, spacetime is interpreted as a coherent phase of the DEQF, and the graviton quantum field (GQF) is the quantized structure of that phase. This identification resolves the quantization of gravity, explains dark matter phenomena through virtual graviton density, and unifies field theory and general relativity in a geometrically emergent context. We introduce the concept of *superasymmetry*, arising from the unidirectional gravitational attraction of gravitons, and derive observational predictions.

1 Introduction

Modern physics is built upon two towering frameworks: quantum field theory (QFT), which governs the behavior of particles and forces at microscopic scales, and general relativity (GR), which describes the large-scale structure and dynamics of spacetime. The two are profoundly successful but fundamentally incompatible. Unifying them into a coherent quantum theory of gravity has remained an open challenge for over a century.

Efforts such as string theory and loop quantum gravity attempt to quantize spacetime or embed it within higher-dimensional structures. Yet these approaches often struggle with background dependence, non-renormalizability, or lack of empirical predictions. In contrast, we take a novel approach: rather than quantizing spacetime directly, we posit that spacetime itself is a phase of a deeper quantum substrate — the Dark Energy Quantum Field (DEQF).

In this model, the graviton field is not a separate entity propagating *on* spacetime, but is the quantized structure *of* spacetime — an excitation of the DEQF in its coherent phase. This removes the contradiction between a smooth classical background and quantum fluctuations, and leads to a natural identification of *quantized spacetime* with the *graviton field*. The consequences unify gravitational, quantum, and cosmological phenomena.

2 Foundations in Graviton Vacuum and Emergent Spacetime

This work builds upon two earlier studies. In "Spacetime as an Emergent Bubble within a Dark Energy Quantum Field," spacetime was modeled as a coherent, self-organizing phase of a deeper field—the DEQF. The DEQF was proposed as the ontological substrate of all other quantum fields and geometric structure. In this view, spacetime arises analogously to a phase boundary or domain within a quantum fluid.

In the companion paper, "Virtual Gravitons and the Emergent Nature of Gravity," it was proposed that virtual gravitons in a quantized graviton field could account for the phenomena typically attributed to dark matter. By introducing an effective stress-energy tensor derived from the graviton vacuum's fluctuations, the model reproduced flat galactic rotation curves, gravitational lensing, and large-scale structure without invoking undetected mass.

These two insights are synthesized here. Spacetime is understood as a coherent phase of the DEQF, and the graviton field is the quantized manifestation of that phase. From this union, gravity emerges not as a fundamental force but as a large-scale expression of virtual graviton density and the asymmetry inherent in their unipolar attraction. This fusion forms the basis of a Grand Unified Field Theory of Asymmetry.

3 The Dark Energy Quantum Field (DEQF)

We define the DEQF as a universal, isotropic quantum field permeating all of existence. Unlike known fields in the Standard Model, the DEQF does not have associated particles in the conventional sense; rather, it acts as the substrate from which particles, spacetime, and even vacuum states emerge.

The DEQF is characterized by the following properties:

- **Stability:** It is eternally present and dynamically stable under vacuum fluctuations.
- **Uniform Ground State:** In its lowest energy configuration, it manifests as the cosmological constant or dark energy.

- **Phase Structure:** It can undergo phase transitions, giving rise to coherent excitations (such as spacetime) or localized particles.

This concept aligns with modern ideas of the quantum vacuum and scalar field condensates but generalizes them to serve as a complete ontological foundation. The DEQF is not *in* spacetime — spacetime is a manifestation *of* the DEQF.

4 Spacetime as a Coherent Phase of the DEQF

We propose that spacetime emerges as a macroscopic phase of the DEQF. This parallels how superfluidity or superconductivity arises from a quantum condensate in condensed matter physics. Just as phonons are excitations of a lattice, spacetime geometry arises as a coherent quantum structure.

Mathematically, the classical metric tensor $g_{\mu\nu}$ corresponds to a vacuum expectation value:

$$g_{\mu\nu} \sim \langle \widehat{h}_{\mu\nu} \rangle_{\text{vac}}, \tag{1}$$

where $\widehat{h}_{\mu\nu}$ is the operator-valued field representing quantum excitations in the spacetime phase of the DEQF. This formulation eliminates the need for a background metric and replaces it with a self-organizing, quantum-consistent structure.

The emergence of spacetime thus results from the collective coherence of DEQF modes, much like emergent order in a Bose–Einstein condensate. Geodesic motion and curvature appear as effective macroscopic phenomena.

5 The Graviton Quantum Field and Quantized Spacetime

5.1 Conceptual identification

We postulate that the graviton quantum field (GQF) $\widehat{h}_{\mu\nu}(x)$ is not an additional entity living *on* spacetime but the quantised structure *of* spacetime itself. Accordingly, a smooth classical metric arises as the vacuum expectation value

$$g_{\mu\nu}(x) = \big\langle 0 \big| \, \widehat{h}_{\mu\nu}(x) \, \big| 0 \big\rangle. \tag{2}$$

Local curvature corresponds to coherent deviations from this expectation value, while gravitational waves correspond to propagating coherent excitations of the same operator.

5.2 Canonical commutation relations

Quantisation proceeds by imposing the equal–time commutator

$$\big[\widehat{h}_{ij}(\mathbf{x}, t), \, \partial_0 \widehat{h}_{kl}(\mathbf{y}, t)\big] = \mathrm{i}\, \hbar \, \delta^3(\mathbf{x} - \mathbf{y}) \, \Pi_{ijkl}, \tag{3}$$

where Π_{ijkl} projects onto the transverse–traceless subspace, ensuring two physical graviton polarisations. These relations endow spacetime itself with a discrete spectrum of curvature quanta.

5.3 Planck–scale saturation

From the properties of the graviton field, the minimal graviton energy quantum is

$$\varepsilon_g = 5.2 \times 10^{-83}\ \mathrm{J}, \tag{4}$$

leading to a force quantum $\mathcal{G} \approx 3.3 \times 10^{-48}\,\mathrm{N}$. At wavelengths approaching the Planck length ℓ_{P}, these quanta saturate: further energy input excites the underlying DEQF rather than producing shorter–wavelength gravitons. This natural cutoff removes the usual ultraviolet divergences of perturbative quantum gravity.

5.4 Effective stress–energy tensor

The vacuum expectation of the GQF two–point function defines an effective stress–energy contribution

$$T^{(\mathrm{vg})}_{\mu\nu} = \alpha\,\hbar\,r^{-2}\,u_\mu u_\nu + \dots, \tag{5}$$

which drives curvature on galactic scales and reproduces flat rotation curves and lensing shear.

5.5 Relation to the DEQF

Inside the spacetime bubble the DEQF condensate takes the form of a rank–two order parameter whose excitations are $\widehat{h}_{\mu\nu}$. Thus

$$\text{DEQF condensate} \;\longrightarrow\; \{g_{\mu\nu},\, \widehat{h}_{\mu\nu}\},$$

6 Modified Einstein Field Equations and Unified Dynamics

By modifying Einstein's field equations to include a stress–energy tensor representing vacuum fluctuations in a quantized graviton field, we effectively integrate general relativity into the framework of quantum field theory. This semiclassical formulation bridges the conceptual gap between classical geometry and quantum dynamics, offering a coherent field-theoretic origin of spacetime curvature.

The graviton vacuum, being unipolar and additive, creates emergent gravitational phenomena — including galactic dynamics and structure formation — without invoking particulate dark matter. The revised Einstein field equations take the form:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \kappa\left(T^{\mathrm{matter}}_{\mu\nu} + T^{(\mathrm{vg})}_{\mu\nu}\right), \tag{6}$$

where $T^{(\mathrm{vg})}_{\mu\nu}$ incorporates the cumulative virtual graviton contribution. This addition modifies large-scale structure evolution while preserving local predictions of general relativity.

7 Pillar I: Graviton Interactions at Planck-Scale Energies

7.1 Why a separate regime matters

In this GUFT the graviton quantum field (GQF) is the quantised structure of spacetime itself. At laboratory energies its quanta behave almost classically, producing curvature described by the modified Einstein equations of Section 6. At the Planck scale, however, individual graviton modes *saturate*: additional energy can no longer be placed into shorter wavelengths but is absorbed by the underlying DEQF in non-geometric degrees of freedom. The transition defines a genuine UV completion of gravity.

7.2 Energy and length thresholds

The usual Planck invariants are

$$\ell_{\mathrm{P}} = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616 \times 10^{-35}\,\mathrm{m}, \qquad E_{\mathrm{P}} = \sqrt{\frac{\hbar c^5}{G}} \approx 1.22 \times 10^{19}\,\mathrm{GeV}. \tag{7}$$

Below E_{P} the spectrum of curvature quanta is discrete; its lowest excitation was fixed in our rotation-curve fit, $\varepsilon_g \simeq 5.2 \times 10^{-83}$ J. For centre-of-mass energies $s \gg E_{\mathrm{P}}^2$ we postulate the *saturation rule*

$$\sigma_{gg}(s) \;\longrightarrow\; 4\pi\ell_{\mathrm{P}}^2,$$

so the graviton–graviton cross-section asymptotes to the geometric area of a Planck disc and cannot diverge.

7.3 Consequences for black holes and singularities

Because no mode with wavelength $\lambda < \ell_{\mathrm{P}}$ exists, gravitational collapse halts when the local curvature reaches $R \simeq \ell_{\mathrm{P}}^{-2}$. The would-be singularity is replaced by a high-temperature DEQF core whose heat capacity is finite; Hawking evaporation is completed by a burst of DEQF quanta rather than an information-destroying singularity.

7.4 Inflationary and particle-physics implications

- **Trans-Planckian censorship**: primordial perturbations with $k > 1/\ell_{\mathrm{P}}$ never enter the semiclassical regime, removing the usual trans-Planckian problem of inflation.
- **Hierarchy stabilisation**: because Standard-Model fields cannot support modes shorter than ℓ_{P}, radiative corrections to the Higgs mass are cut off at E_{P} *by construction*, without supersymmetry.

7.5 Observational windows

1. A universal upper limit $\sigma_{pp\to\mathrm{BH}} < 4\pi\ell_{\mathrm{P}}^2$ for micro-black-hole production in ultra-high-energy cosmic-ray events.
2. A damping tail in the tensor power spectrum above $\ell \gtrsim 3000$ in future CMB B-mode surveys, reflecting the graviton cutoff.
3. Possible sub-Planckian remnants from evaporating primordial black holes, appearing as 10^{19} GeV bursts of DEQF quanta in very-high-energy gamma-ray observatories.

This completes the first pillar: gravity self-regularises through graviton saturation, making the Planck scale a *physical* rather than merely formal boundary.

8 Pillar II: Planck-Scale Cutoff and Regularization

The identification of spacetime as a coherent phase of the graviton quantum field (GQF) has profound implications for ultraviolet (UV) behavior in gravitational physics. In this framework, the smooth metric geometry of classical general relativity arises only as a coarse-grained limit of a fundamentally discrete and quantized structure.

Because spacetime itself is emergent from quantum fluctuations in the DEQF, there exists a minimal length scale below which the geometric notion of spacetime ceases to apply. This natural cutoff is associated with the saturation point of graviton field modes—beyond which additional energy does not lead to smaller wavelengths, but instead excites deeper, non-geometric modes of the DEQF.

This intrinsic cutoff is identified with the Planck length:

$$\ell_{\mathrm{P}} = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616 \times 10^{-35}\,\mathrm{m}, \tag{8}$$

which represents the fundamental scale at which the graviton field transitions from geometric excitation to non-spatial energy density.

Unlike in conventional approaches where UV divergences are tamed via renormalization or arbitrary regularization schemes, here the breakdown of classical spacetime is a physical consequence of the theory. As graviton wavelengths approach ℓ_{P}, the field saturates, and the underlying DEQF absorbs excess energy without contributing to curvature or propagation.

This mechanism removes the need for external cutoffs and provides a physical explanation for the non-divergent behavior of quantum gravity at high energies. Black hole singularities, vacuum energy divergences, and trans-Planckian inflationary modes are all naturally avoided within this formulation.

In this view, quantum gravity is not an extrapolation of classical gravity to higher energies—it is a fundamentally different regime, governed by the saturation dynamics of the graviton field within the DEQF condensate.

9 Pillar III: Compatibility with the Standard Model

The Grand Unified Field Theory (GUFT) described herein is designed not to replace the Standard Model (SM), but to provide a deeper ontological substrate from which the Standard Model itself could emerge. While the DEQF and its graviton phase govern spacetime and gravity, their interactions with Standard Model fields occur through coherent background effects, boundary constraints, and virtual graviton field interactions.

The gauge symmetries of the Standard Model ($SU(3)_C imes SU(2)_L imes U(1)_Y$) are preserved within the emergent spacetime structure. The virtual graviton field contributes to curvature and background energy, but not to gauge boson dynamics at leading order. However, in regions of extreme spacetime distortion—near black holes or early-universe conditions—non-trivial coupling between the graviton condensate and SM gauge fields may occur.

Moreover, the energy scale associated with graviton field saturation at the Planck length places a natural cutoff beyond which Standard Model interactions dissolve into DEQF excitations. This resolves the hierarchy problem without supersymmetry: fermion and boson fields are emergent structures stable only within a coherent spacetime phase. Beyond this, all fields reduce to fluctuations in the DEQF.

10 Pillar IV: Cosmological Implications

10.1 Inflation and the DEQF vacuum

In standard inflationary models, a scalar field (the inflaton) drives exponential expansion via its potential energy. In the GUFT framework, inflation is interpreted as a rapid phase transition

in the DEQF. As spacetime emerges from the DEQF condensate, quantum fluctuations on the DEQF surface produce the seeds of structure formation. The inflationary phase corresponds to a metastable excited state of the DEQF before settling into its current vacuum expectation value.

Because of graviton saturation at the Planck scale, trans-Planckian modes are never excited, resolving the trans-Planckian problem. The largest-scale fluctuations are imprinted by the early coherence dynamics of the graviton condensate, naturally generating a nearly scale-invariant power spectrum with slight deviations due to residual DEQF inhomogeneities.

10.2 Cosmological constant as vacuum energy

The DEQF, in its lowest-energy phase, contributes a nonzero energy density interpreted macroscopically as the cosmological constant Λ. Unlike traditional quantum field theory predictions that overshoot the observed value by over 100 orders of magnitude, the GUFT framework bounds vacuum energy by the saturation dynamics of the graviton field. The effective cosmological constant arises from the stable equilibrium of the DEQF in the spacetime phase:

$$\Lambda_{\text{eff}} = 8\pi G \, \langle \rho_{\text{DEQF}} \rangle_{\text{vac}}.$$

Here, ρ_{DEQF} is the background vacuum energy density associated with the coherent phase of the DEQF.

10.3 Dark energy as a phase property

Rather than being an unknown component or scalar field, dark energy is simply the latent vacuum pressure of the DEQF itself. It reflects the fact that spacetime remains in a coherent low-temperature phase of a broader quantum fluid. The apparent acceleration of the universe is the result of pressure gradients and DEQF boundary dynamics across cosmological domains.

10.4 Dark matter as virtual graviton pressure

As previously developed in our graviton field model, the curvature attributed to dark matter can be modeled by an effective stress-energy tensor arising from virtual graviton density. This replaces the need for exotic non-baryonic particles, providing a natural explanation for:

- Flat galactic rotation curves,
- Gravitational lensing of clusters,
- Large-scale structure formation.

This effective graviton pressure is a manifestation of vacuum energy anisotropy, regulated by the DEQF phase coherence and saturation dynamics.

10.5 Horizon structure and DEQF bubbles

The large-scale isotropy of the observable universe suggests the DEQF underwent a globally coherent phase transition, yielding causally connected domains we now observe. Cosmic horizons can thus be interpreted not as fundamental limits but as the edge of a contiguous spacetime bubble embedded in a broader non-spatial quantum substrate.

10.6 Testable consequences

- Slight departures from ΛCDM expansion at late times, due to DEQF phase gradients across superhorizon scales.
- Suppression of tensor modes beyond $\ell > 3000$ in CMB B-mode spectra.
- Absence of dark matter particle detection in direct experiments.
- Potential correlations between large-scale curvature and void distributions consistent with DEQF boundary dynamics.

This completes the fourth foundational pillar of the GUFT: a cosmology grounded in DEQF phase structure, in which inflation, dark energy, and dark matter are unified phenomena arising from the same underlying quantum field.

11 Testable Predictions

While the GUFT model is ontologically novel, it yields specific, testable consequences across multiple domains of observational and experimental physics. These predictions distinguish it from both classical general relativity and standard quantum field theory:

11.1 Absence of Dark Matter Particles

- No WIMP, axion, or sterile neutrino candidates will be detected in direct searches.
- Gravitational anomalies currently ascribed to dark matter (e.g., galactic rotation curves, lensing profiles) should instead correlate with virtual graviton density.

11.2 CMB Polarization and B-mode Suppression

- The graviton saturation cutoff implies a suppression of tensor modes at small scales.
- Cosmic Microwave Background (CMB) B-mode spectra beyond $\ell > 3000$ should show anomalous damping inconsistent with standard inflationary models.

11.3 Modified Expansion History

- Late-time cosmic acceleration may deviate slightly from ΛCDM predictions due to DEQF phase gradients.
- BAO and supernova surveys should observe subtle shifts in the Hubble parameter $H(z)$ at redshifts $z > 1.5$.

11.4 Gravitational Wave Propagation

- Long-range gravitational wave dispersion may occur in regions with fluctuating DEQF phase coherence.
- Slight violations of Lorentz invariance may be observable in gravitational wave phase shifts across different directions or polarizations.

11.5 Minimal Length Scale Effects

- Planck-scale limits on spatial resolution may manifest in quantum interference experiments.
- No trans-Planckian frequencies should arise in black hole evaporation or inflationary fluctuation spectra.

11.6 Structure Formation Without Cold Dark Matter

- N-body simulations using virtual graviton effective pressure instead of cold dark matter will match LSS distributions.
- Halo mass functions should show suppression of low-mass substructure consistent with quantum graviton saturation limits.

These measurable consequences offer falsifiable tests of the theory, distinguishing it from both Standard Model cosmology and competing quantum gravity proposals. As precision observations improve, the GUFT framework stands to be confirmed or refuted through real-world data.

12 The Beauty of Asymmetry

In contrast to the long-standing pursuit of a universe governed by the perfect balance of supersymmetry — where every fermion has a boson, and every interaction is mirrored in elegant dualities — this theory embraces a deeper, more subtle order: superasymmetry.

Here, the universe emerges not from the cancellation of opposites, but from the coherence of imbalance. The graviton, unlike the photon, has no opposite. Its fluctuations do not neutralize; they accumulate, shaping the very fabric of spacetime.

Thus, we glimpse a cosmos not defined by symmetry, but born of asymmetry — a universe where curvature arises not from the absence of mass, but from the presence of quantum imbalance in the gravitational vacuum.

There is profound mathematical beauty in this asymmetry. Not because it is chaotic, but because it is structured, generative, and real.

In this view, gravity is not merely a force — it is the signature of the universe's most elegant imperfection.

References

[1] James Scott Trimm, *Spacetime as an Emergent Bubble Within a Fundamental Dark Energy Quantum Field*, Independent Publication, April 26, 2025.

[2] James Scott Trimm, *Virtual Gravitons and the Emergent Nature of Gravity*, Independent Publication, June 26, 2025.